Defense Forensic Science Center

Towards Integrating Probabilistic Logic and Quantitative Data Into Practice: Latent Print Examination

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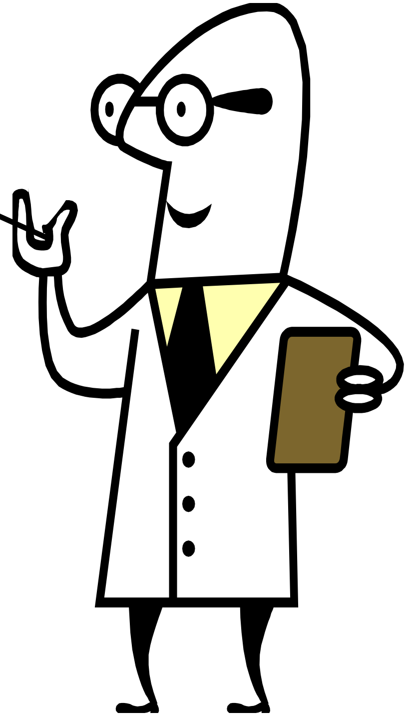
Fingerprint Examination 101

Fingerprints 101

Two prints can be identified to the same source when there is sufficient quantity and quality of ridge detail in agreement



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The problem . . .

What is "Sufficient"?

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The issue . . .

- There are no generally accepted criteria or standardized practice for:
  - **What is being evaluated?**
  - **How it is being evaluated?**
  - **What it means?**
  - **How it can be demonstrated?**

The Issue . . .

The issue isn't that we don't know what to look for . . .

The issue is that we haven't standardized the practice or perform it in a clear & transparent manner

. . . But first, we must find a way to describe the data (quantify)

A solution?

Quantification of Evidence

$$\frac{p(\mathcal{H}_1 \mid E) = p(E \mid \mathcal{H}_1) \; x \; p(\mathcal{H}_1)}{p(\mathcal{H}_2 \mid E) = p(E \mid \mathcal{H}_2) \; x \; p(\mathcal{H}_2)}$$

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A solution?

What can we do today?

- Focus on incremental steps
- Quantify what we can and use it within its appropriate scope so that we can begin to standardize the practice
- Embrace continuous improvement

Defining “sufficient”

Four objectives:

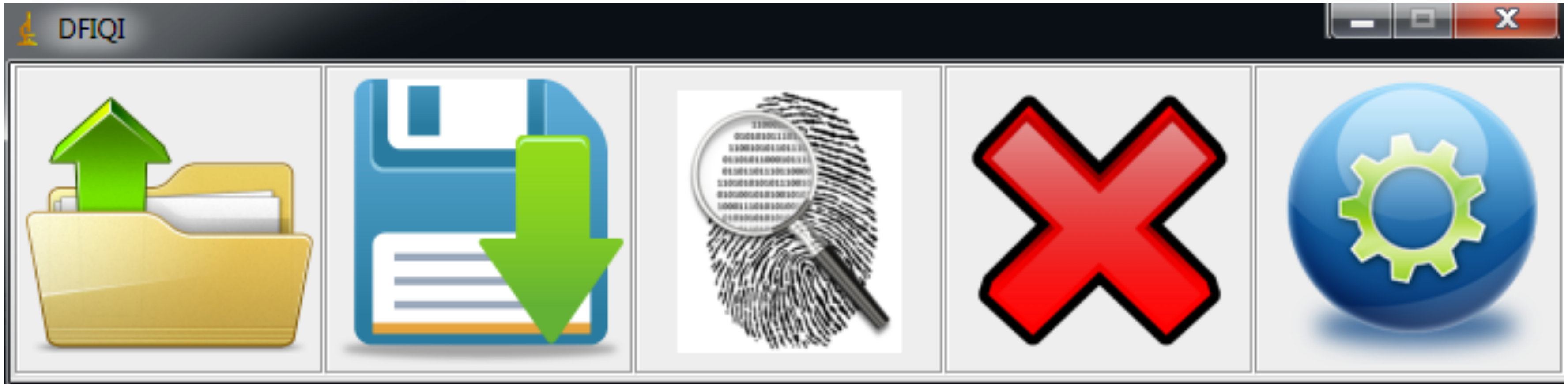
(1) Develop a tool capable of measuring correspondence of fingerprint features

(2) Evaluate how dissimilar prints can be when made from the **same** source

(3) Evaluate how similar prints can be when made from **different** sources

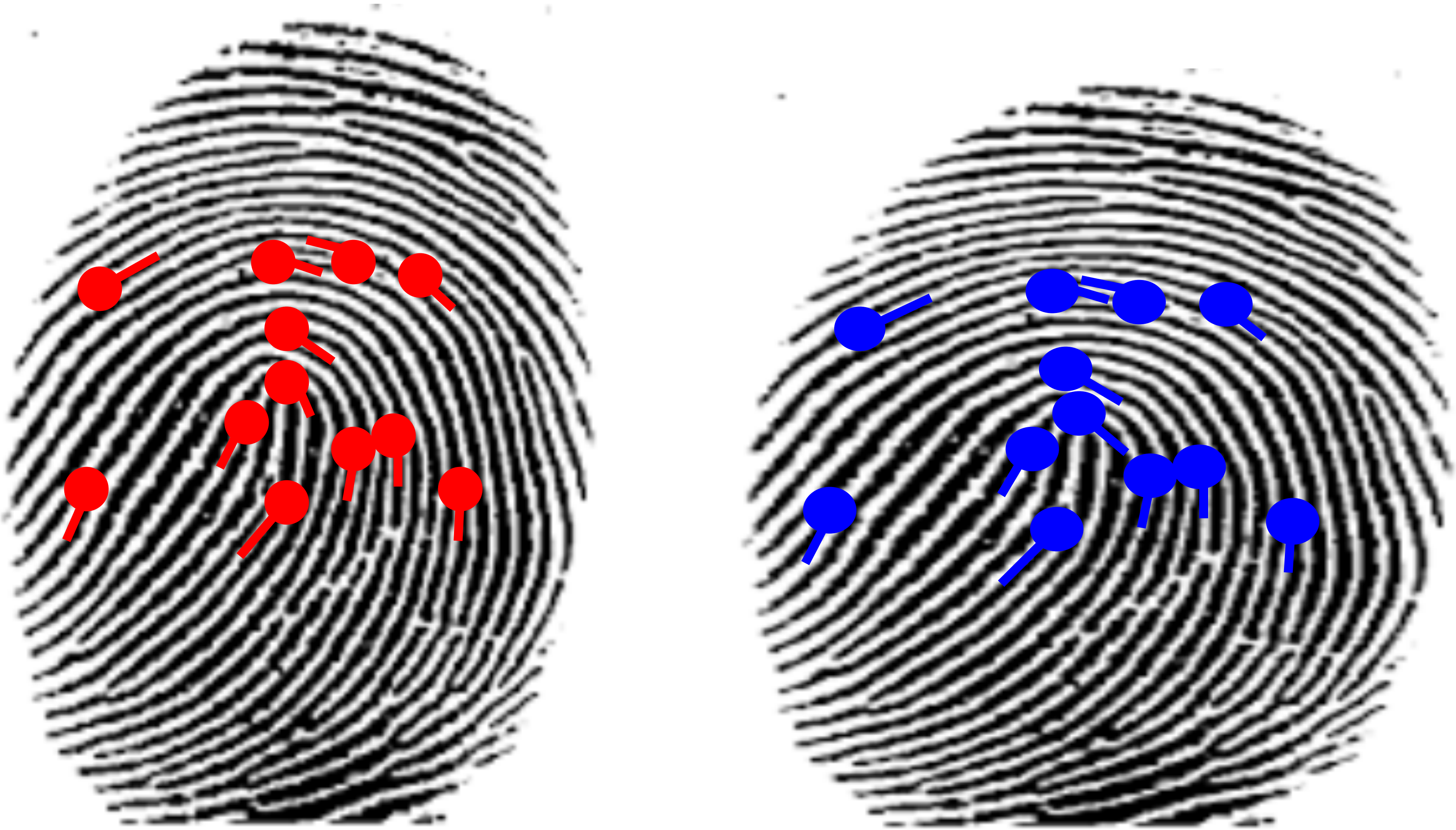
(4) Quantify the value of fingerprint correspondence in relation to the range of expected results under the conditions of same source and different source impressions

Defense Fingerprint Image Quality Index (DFIQI)



Evaluation Module

DFIQI – Conceptual Overview



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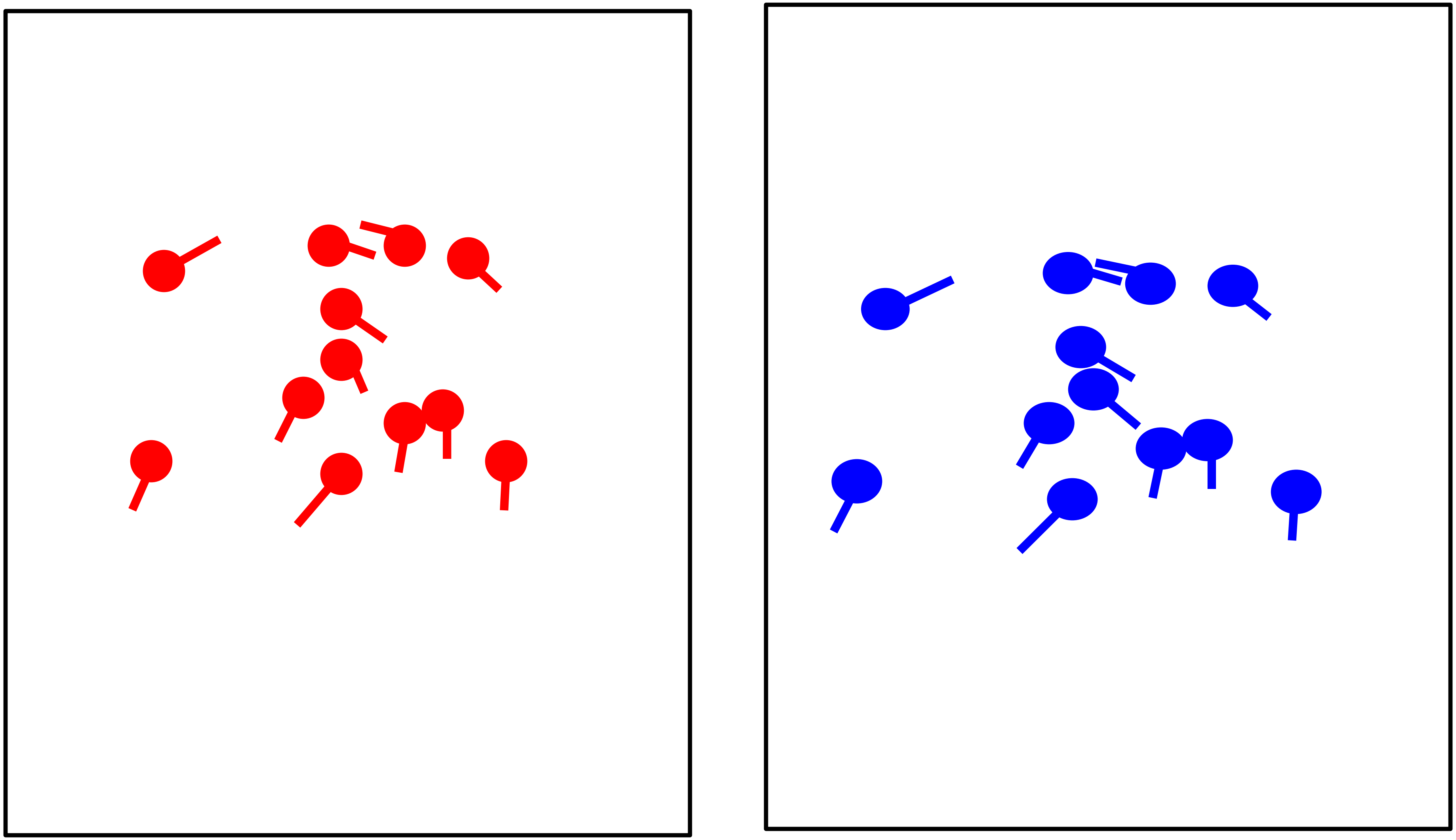
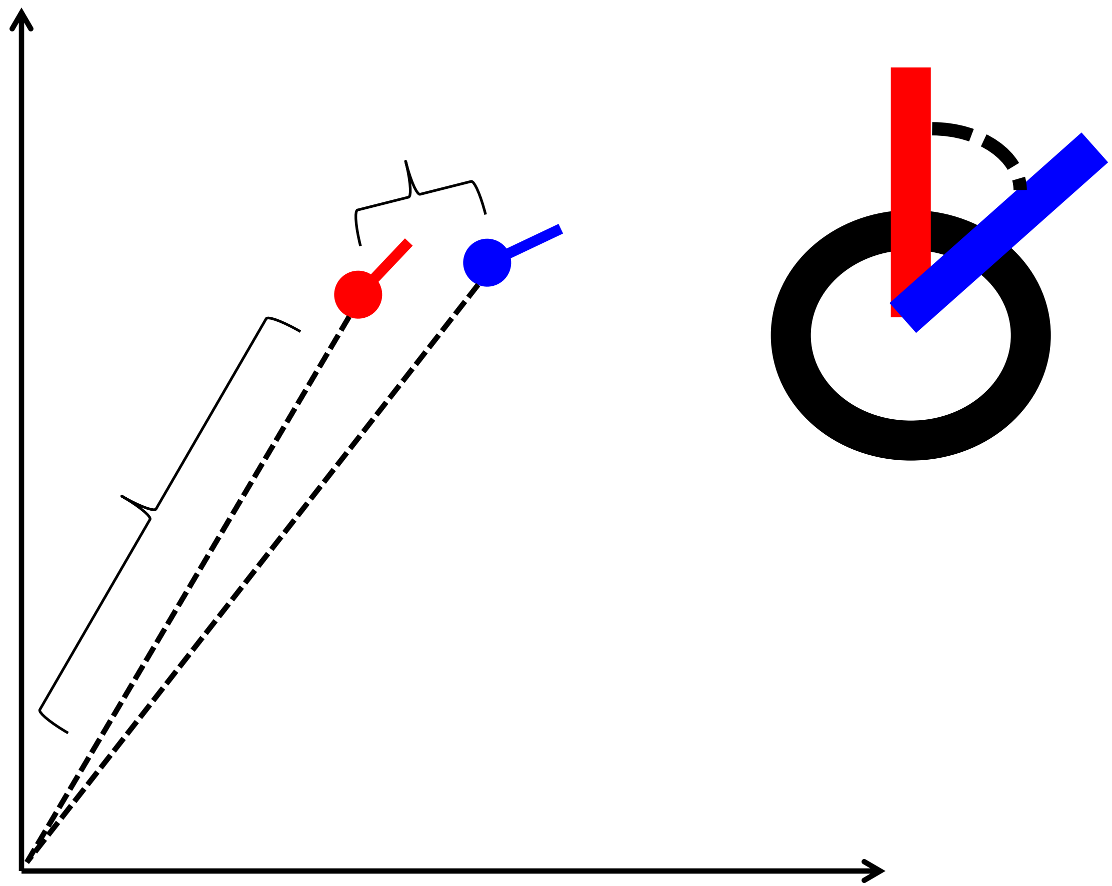
DFIQI – Conceptual Overview



DFIQI – Conceptual Overview



Now we know *WHAT* we are evaluating and *HOW* we do it . . .

We can summarize high-dimensional data into a single, summarized statistic (i.e. "similarity score")

. . . ***How does it perform and what does it mean?***

Intra-Source variability

Intra-Source Variability

a. Repeated impressions from the same source collected on live-scan device at 500ppi:

- Fifty different individuals (right thumb)
- One "flat" impression (non-distorted)
- Ten different "distorted" impressions
- Fifteen corresponding features annotated by latent print examiners
- Distorted image compared against non-distorted "flat" image

Intra-Source variability

Compare against several distorted prints from the same source

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Inter-Source variability

Inter-Source Variability

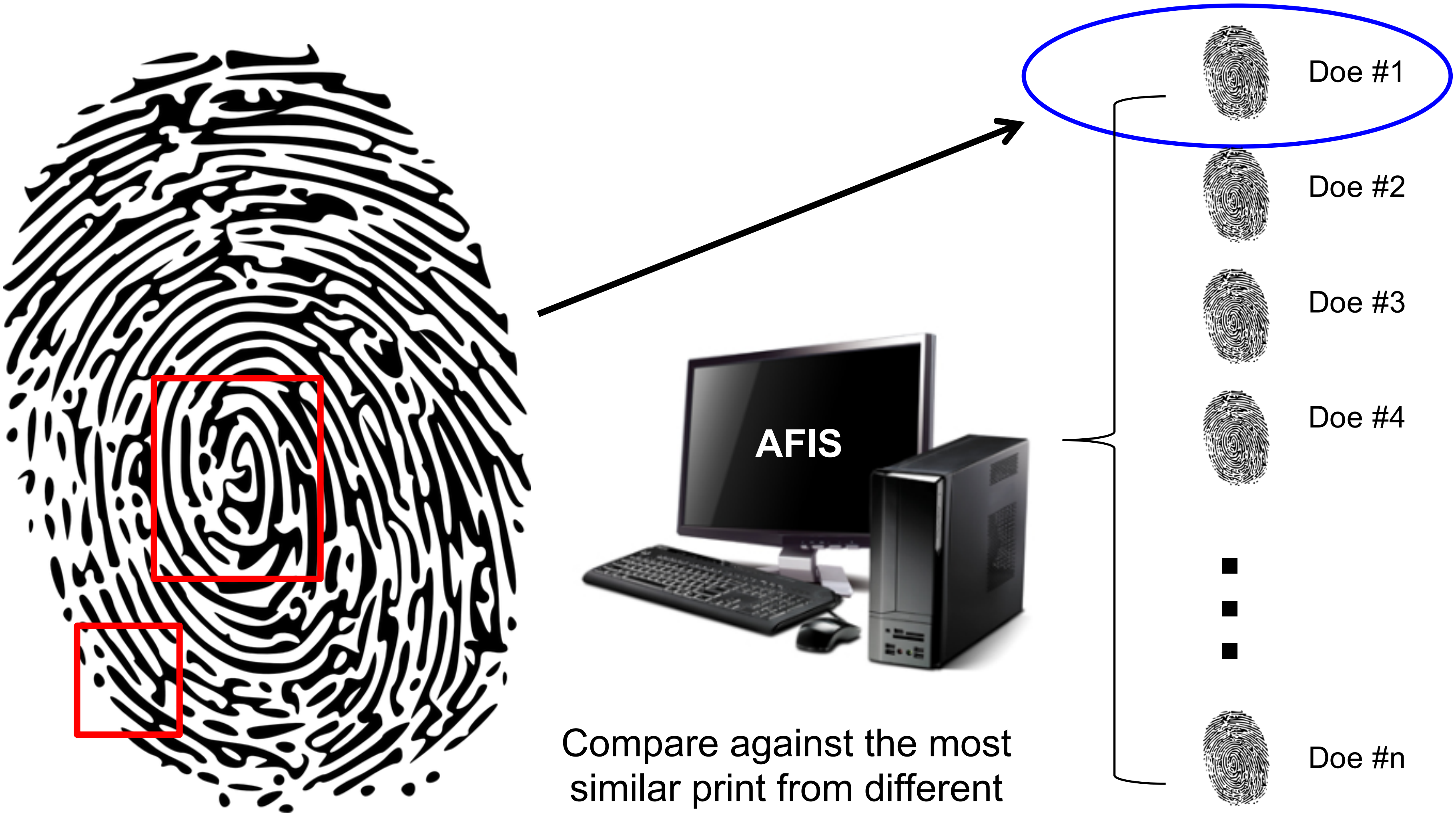
a. 200 Fingerprint images
   a. 100 representing the “core” region of a fingerprint
   b. 100 representing the “delta” region of a fingerprint

b. *n* fingerprint features were annotated on each impression, cropped down to only a partial impression represented by the annotated features, and searched through a operational AFIS database (database contains ~12,000,000 individuals; ~100,000,000 different fingerprints)

c. The #1 search candidate was exported (most similar candidate according to AFIS algorithms). New search for each quantity of features (n range from 5 – 15 features)

d. *m* fingerprint features were annotated on the candidate result – annotations performed indiscriminately across the core and delta, respectively (where $m > n+5$)

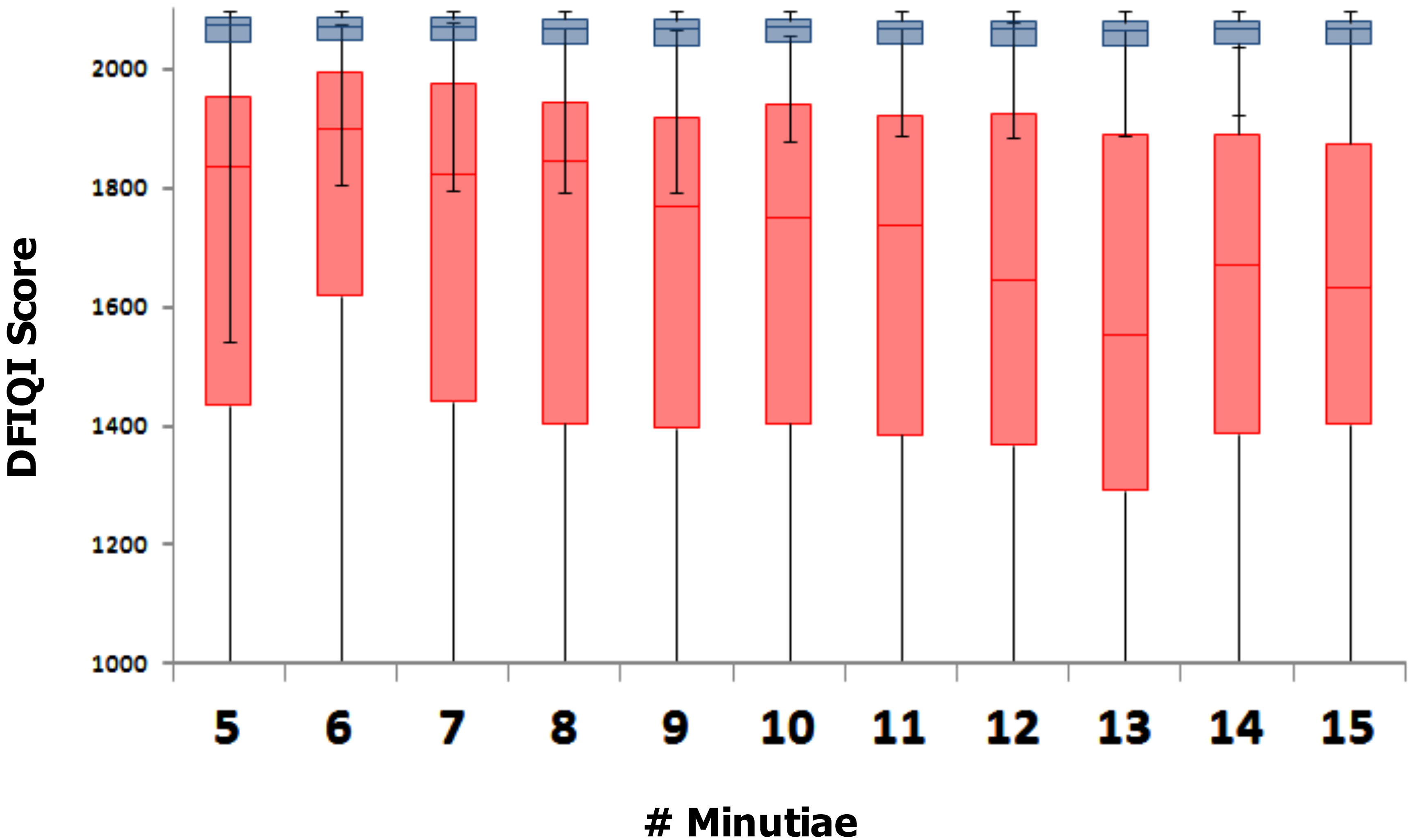
Inter-Source variability



Compare against the most similar print from different sources (~100,000,000 prints)

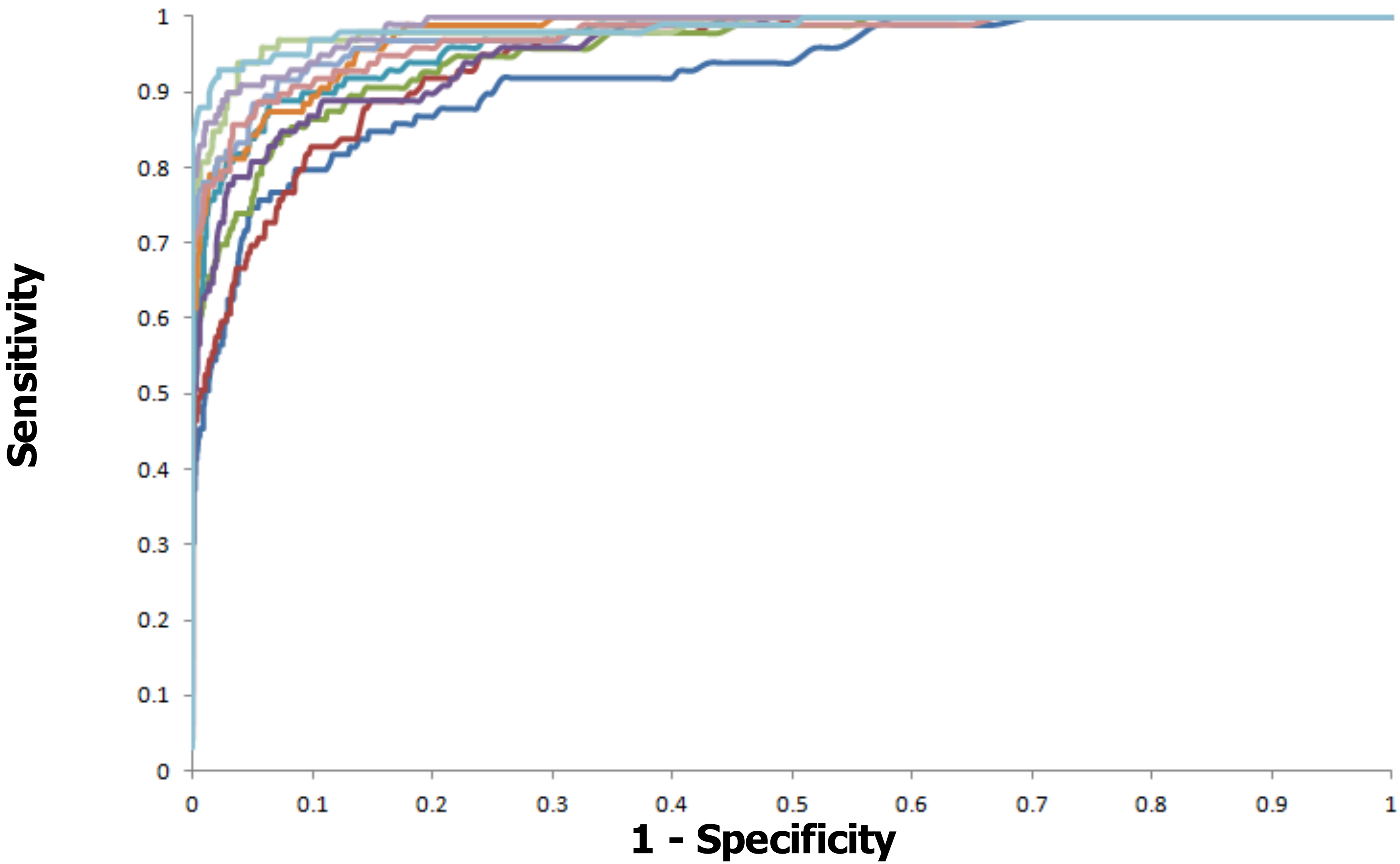
Intra- & Inter-Source variability

Intra & Inter-Source Variability (Delta)



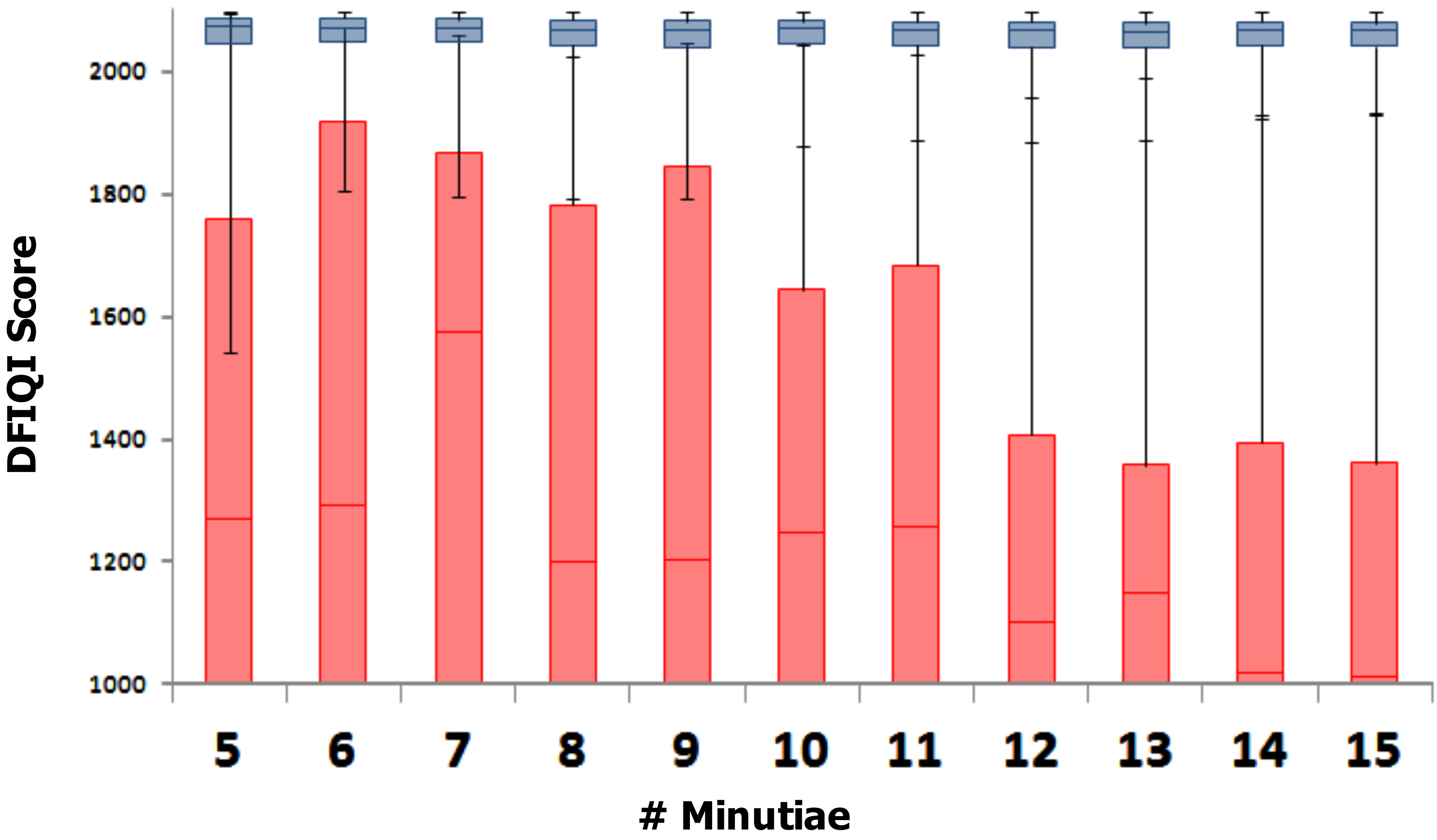
Intra- & Inter-Source variability

Intra & Inter-Source Variability (Delta)



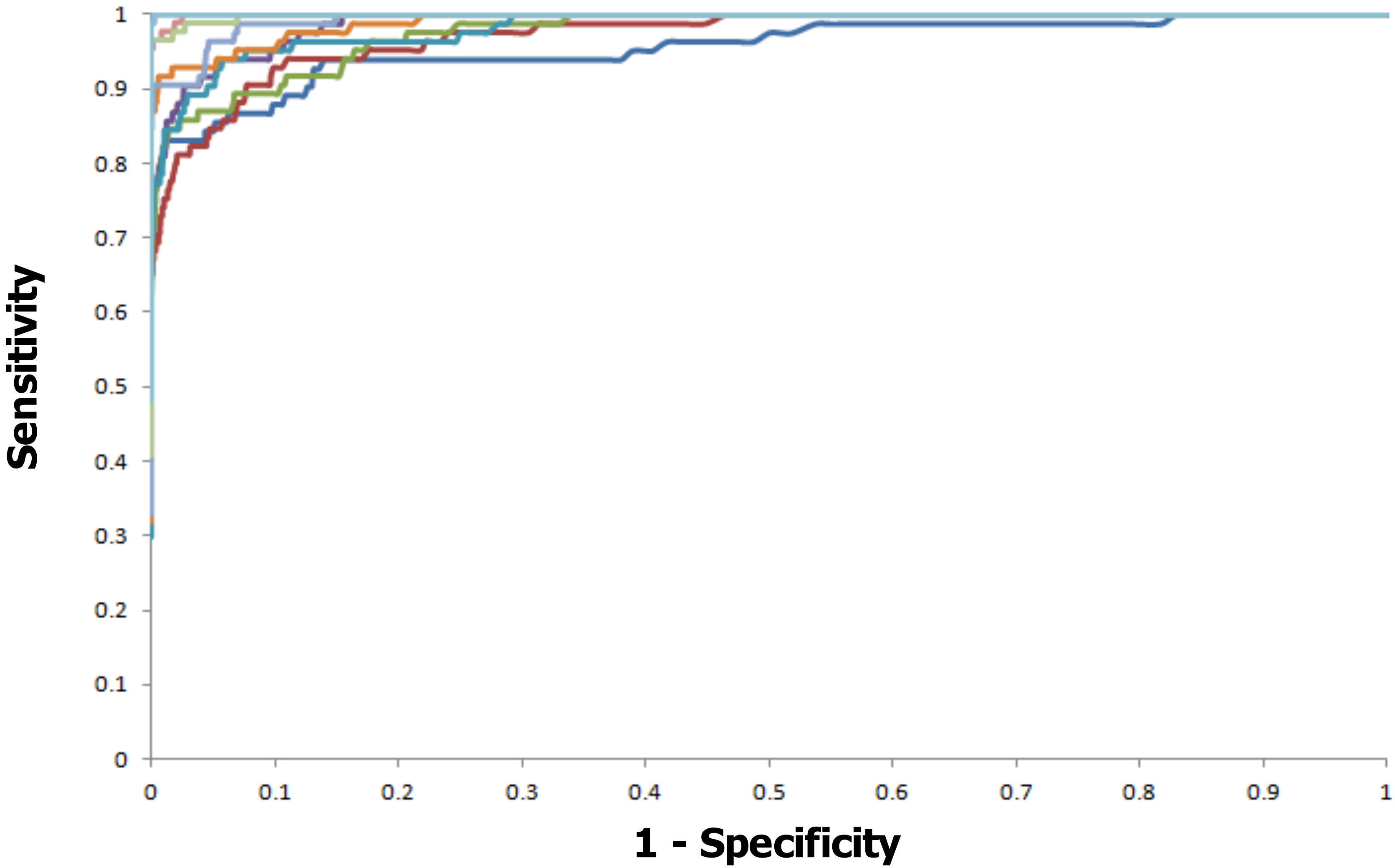
Intra- & Inter-Source variability

Intra & Inter-Source Variability (Core)



Intra- & Inter-Source variability

Intra & Inter-Source Variability (Core)



Next Steps

Continue working with relevant statisticians, academia, and legal stakeholders to identify the appropriate scope of use

Integrate into casework operations as a means of quantifying, defining, and standardizing practice

Transition technology into public domain for use by other federal, state, local agencies with the intent to help advance the discipline at large

NIST Clock Experiment Demonstrates That Your Head is Older Than Your Feet

For Immediate Release: September 28, 2010

Contact: Laura Ost
303-497-4880

Scientists have long known that time passes faster at higher elevations—a curious aspect of Einstein's theories of relativity that previously has been measured by comparing clocks on the Earth's surface and a high-flying rocket. Now, physicists at the National Institute of Standards and Technology (NIST) have measured this effect at a more down-to-earth scale of 33 centimeters, or about 1 foot, demonstrating, for instance, that you age faster when you stand a couple of steps higher on a staircase.

Described in the Sept. 24 issue of *Science*,* the difference is much too small for humans to perceive directly—adding up to approximately 90 billionths of a second over a 79-year lifetime—but may provide practical applications in geophysics and other fields. The NIST researchers also observed another aspect of relativity—that time passes more slowly when you move faster—at speeds comparable to a car travelling about 20 miles per hour, a more comprehensible scale than previous measurements made using jet aircraft.

NIST scientists performed the new "time dilation" experiments by comparing operations of a pair of the world's best experimental atomic clocks. The nearly identical clocks are each based on the "ticking" of a single aluminum ion as it vibrates between two energy levels over a million billion times per second. One clock keeps time to within 1 second in about 3.7 billion years (see NIST announcement from Feb. 4, 2010, "NIST's Second 'Quantum Logic Clock' Based on Aluminum Ion is Now World's Most Precise Clock" at http://www.nist.gov/physlab/div847/logicclock_020410.cfm) and the other is close behind in performance. The clocks are precise and stable enough to reveal slight differences that could not be seen until now.

The NIST experiments test two predictions of Einstein's theories of relativity. First, when two clocks are subjected to unequal gravitational forces due to their different elevations above the surface of the Earth, the higher clock—experiencing a smaller gravitational force—runs faster. Second, when an observer is moving, a stationary clock's tick appears to last longer, so the clock appears to run slow. Scientists refer to this as the "twin paradox," in which a twin sibling who travels on a fast-moving rocket ship would return home younger than the other twin.

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